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Program TRAMO

"**T**ime Series **R**egression with **ARIMA** Noise,
Missing Observations, and **O**utliers"

Instructions for the User

(Preliminary Version: September 1994)

by

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Abstract

The present document contains a brief summary and the user instructions for the Program TRAMO, a program for estimation and forecasting of regression models with nonstationary (ARIMA) errors. The program also computes optimal interpolators for any possible sequence of missing observations, and identifies and corrects for several types of outliers and special effects (such as trading day and Easter effect). The program contains a facility for automatic model identification. It can, thus, be used for detailed analysis of a few series, or for routine applications to many series (for example, as an efficient preadjustment program in seasonal adjustment).

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Contents

1 Brief Description of the Program*

TRAMO ("Time Series Regression with ARIMA Noise, Missing Observations, and Outliers") is a program written in Fortran for mainframes and PCs under MsDos. The program performs estimation, forecasting, and interpolation of regression models with missing observations and ARIMA errors, in the presence of possibly several types of outliers. The ARIMA model can be identified automatically. (No restriction is imposed on the location of the missing observations in the series.)

Given the vector of observations:

$$z = (z_{t_1}, \ldots, z_{t_M}) \tag{1}$$

where $0 < t_1 < \ldots < t_M$, the program fits the regression model

$$z_t = y_t' \beta + \nu_t, \tag{2}$$

where $\beta = (\beta_1, \ldots, \beta_n)'$ is a vector of regression coefficients, $y_t' = (y_{1t}, \ldots, y_{nt})$ denotes n regression variables, and ν_t follows the general ARIMA process

$$\phi(B)\, \delta(B)\, \nu_t = \theta(B)\, a_t + c, \tag{3}$$

where B is the backshift operator; $\phi(B)$, $\delta(B)$, and $\theta(B)$ are finite polynomials in B; a_t is assumed a n.i.i.d. $(0, \sigma_a^2)$ white–noise innovation, and c is a constant.

The polynomial $\delta(B)$ contains the unit roots associated with differencing (regular and seasonal), $\phi(B)$ is the polynomial with the stationary autoregressive roots (and the complex unit roots, if present), and $\theta(B)$ denotes the (invertible) moving average polynomial. In TRAMO, they assume the following multiplicative form:

$$\begin{aligned}
\delta(B) &= (1-B)^d\, (1-B^s)^D \\
\phi(B) &= (1+\phi_1 B + \ldots + \phi_p B^p)\, (1+\Phi_1\, B^s + \ldots + \Phi_P\, B^{s\times P}) \\
\theta(B) &= (1+\theta_1 B + \ldots + \theta_q B^q)\, (1+\Theta_1\, B^s + \ldots + \Theta_Q\, B^{s\times Q}),
\end{aligned}$$

where s denotes the number of observations per year.

As explained in Section 3.1, initial estimates of the parameters can be input by the user, set to the default values, or computed by the program.

The regression variables can be input by the user (such as economic variables thought to be related with z_t), or generated by the program. The variables that can be generated are trading day, easter effect and intervention variables of the type:

*Thanks are due to Gianluca Caporello for his computing assistance.

a) dummy variables (additive outliers);

b) any possible sequence of ones and zeros;

c) $1/(1-\delta B)$ of any sequence of ones and zeros, where $0 < \delta \leq 1$;

d) $1/(1-\delta_s B^s)$ of any sequence of ones and zeros, where $0 < \delta_s \leq 1$;

e) $1/(1-B)\,(1-B^s)$ of any sequence of ones and zeros.

The program:

1) estimates by exact maximum likelihood (or unconditional/conditional least squares) the parameters in (2) and (3);

2) detects and corrects for several types of outliers;

3) computes optimal forecasts for the series, together with their MSE;

4) yields optimal interpolators of the missing observations and their associated MSE; and

5) contains an option for automatic model identification and automatic outlier treatment.

The basic methodology followed is described in Gómez and Maravall (1994). Additional documentation is contained in Gómez and Maravall (1992) and Gómez (1994).

Estimation of the regression parameters (including intervention variables and outliers, and the missing observations among the initial values of the series), plus the ARIMA model parameters, can be made by concentrating the former out of the likelihood, or by joint estimation. Several algorithms are available for computing the likelihood or more precisely, the nonlinear sum of squares to be minimized. When the differenced series can be used, the algorithm of Morf, Sidhu and Kailath (1974) (with a simplification similar to that of Mélard, 1984) is employed.

For the nondifferenced series, it is possible to use the ordinary Kalman filter (default option), or its square root version (see Anderson and Moore, 1979). The latter is adequate when numerical difficulties arise; however it is markedly slower.

By default, the exact maximum likelihood method is employed, and the unconditional and conditional least squares methods are available as options. Nonlinear maximization of the likelihood function and computation of the parameter estimates standard errors is made using Marquardts method and first numerical derivatives.

Estimation of regression parameters is made by using first the Cholesky decomposition of the inverse error covariance matrix to transform the regression equation (the Kalman filter provides an efficient algorithm to compute the variables in this transformed regression). Then, the resulting least squares problem is solved by orthogonal matrix factorization using the Householder transformation. This procedure yields an efficient and numerically stable method to compute GLS estimators of the regression parameters, which avoids matrix inversion.

For forecasting, the ordinary Kalman filter or the square root filter options are available. Interpolation of missing values is made by a simplified Fixed Point Smoother, and yields identical results to Kohn and Ansley (1986); for a more detailed discussion, see Gómez and Maravall (1993). When concentrating the regression parameters out of the likelihood, mean squared errors of the forecasts and interpolations are obtained following the approach of Kohn and Ansley (1985).

When some of the initial missing values are unestimable (free parameters), the program detects them, and flags the forecasts or interpolations that depend on these free parameters. The user can then assign arbitrary values (typically, very large or very small) to the free parameters and rerun the program. Proceeding in this way, all parameters of the ARIMA model can be estimated because the function to minimize does not depend on the free parameters. Moreover, it will be evident which forecasts and interpolations are affected by these arbitrary values because they will strongly deviate from the rest of the estimates. However, if all unknown parameters are jointly estimated, the program may not flag all free parameters. It may happen that there is convergence to a valid arbitrary set of solutions (i.e., that some linear combinations of the initial missing observations, including the free parameters, are estimable.)

As indicated in Section 3.5, missing observations can also be treated as additive outliers. In this case, the likelihood can be corrected so that it coincides with that of the standard missing–observations case.

The program has a facility for detecting outliers and for removing their effect; the outliers can be entered by the user or they can be automatically detected by the program, using an approach similar to that of Chen and Liu (1993), with some important modifications incorporated. In brief, regression parameters are initialized by OLS, and then the ARMA model parameters are estimated with two regressions, as in Hannan and Rissanen (1982). Next, the Kalman filter provides the series residuals, and new regression parameter estimates are obtained. For each observation, t–tests are computed for four types of outliers, as in Chen and Liu (1993). Outliers are removed one by one and, each time, new model parameter estimates are obtained. Once this first sequence has been completed, a multiple regression is performed and, if some outliers are eliminated, the program goes back to the first sequence, and iterates in this way until no more outliers are eliminated in the multiple regression.

A notable feature of this algorithm is that all calculations are based on linear regression techniques, which reduces computational time. The four types of outliers considered are additive outlier, innovational outlier, level shift, and transitory change.

Finally, the program contains a facility for automatic identification of the ARIMA model. This is done in two steps. The first one yields the nonstationary polynomial $\delta(B)$ and the constant c of model (3). This is done by iterating on a sequence of AR and ARMA(1, 1) models (with mean), which have a multiplicative structure when the data is seasonal. The procedure is based on results of Tiao and Tsay (1983, Theor. 3.2 and 4.1), and Tsay (1984, Corol. 2.1). Regular and seasonal differences are obtained, up to a maximum order of $\nabla^2 \nabla_s$. The program also checks for possible complex unit roots at nonzero and nonseasonal frequencies.

The second step identifies an ARMA model for the stationary series (corrected for outliers and regression–type effects) following the Hannan–Rissanen procedure, with some modifications. For the general multiplicative model

$$\phi_p(B)\,\Phi_P(B^s)\,x_t = \theta_q(B)\,\Theta_Q(B^s),$$

the search is made over the range $0 \le (p, q) \le 3, \quad 0 \le (P, Q) \le 2$. This is done sequentially (for fixed regular polynomials, the seasonal ones are obtained, and viceversa), and the final orders of the polynomials are chosen according to a BIC criterion, with some possible constraints aimed at increasing parsimony and favoring "balanced" models (similar AR and MA orders).

TRAMO has been designed so that it can be used with a companion program named SEATS ("Signal Extraction in ARIMA Time Series"), described in Maravall and Gómez (1992). SEATS is an ARIMA–model–based method for estimation of unobserved components (trend, cyclical, seasonal, and irregular component), and in particular for seasonal adjustment. Since the method applies to linear time series, TRAMO can be seen as a preadjustment program, that produces the linear series for SEATS. Since both programs can handle routine applications to a large number of series, they provide a fully model–based alternative to REGARIMA and X11ARIMA, that form the new Census X12 procedure (see Findley et al., 1992). Program SEATS, and more detailed documentation on both programs, is available from the authors.

References

ANDERSON, B. and MOORE, J. (1979), *Optimal Filtering*, New Jersey: Prentice Hall.

BOX, G.E.P. and JENKINS, G.M. (1970), *Time Series Analysis: Forecasting and Control*, San Francisco: Holden–Day.

BOX, G.E.P. and TIAO, G.C. (1975), "Intervention Analysis with Applications to Economic and Environmental Problems", *Journal of the American Statistical Association* 70, 71–79.

BURMAN, J.P. (1980), "Seasonal Adjustment by Signal Extraction", *Journal of the Royal Statistical Society* A, 143, 321–337.

CHEN, C. and LIU, L.M. (1993), "Joint Estimation of Model Parameters and Outlier Effects in Time Series", *Journal of the American Statistical Association* 88, 284–297.

CHEN, C., LIU, L.M. and HUDAK, G.B. (1990), "Outlier Detection and Adjustment in Time Series Modeling and Forecasting", Working Paper and Reprint Series, Scientific Computing Associates, Lyle (IL), August 1990.

FINDLEY, D.F., MONSELL, B., OTTO, M., BELL, W. and PUGH, M. (1992), "Towards X–12 ARIMA", mimeo, Bureau of the Census.

GÓMEZ, V. (1994), "Especificación Automática de Modelos ARIMA en Presencia de Observaciones Atípicas", mimeo, Departamento de Estadística e I.O., Universidad Complutense de Madrid, June 1994.

GÓMEZ, V. and MARAVALL, A. (1992), "Time Series Regression with ARIMA Noise and Missing Observations — Program TRAM", EUI Working Paper ECO No. 92/81, Department of Economics, European University Institute.

GÓMEZ, V. and MARAVALL, A. (1993), "Initializing the Kalman Filter with Incompletely Specified Initial Conditions", in Chen, G.R. (ed.), *Approximate Kalman Filtering (Series on Approximation and Decomposition)*, London: World Scientific Publ. Co.

GÓMEZ, V. and MARAVALL, A. (1994), "Estimation, Prediction and Interpolation for Nonstationary Series with the Kalman Filter", *Journal of the American Statistical Association* 89, 611–624.

HANNAN, E.J. and RISSANEN, J. (1982), "Recursive Estimation of Mixed Autoregressive–Moving Average Order", *Biometrika* 69, 81–94.

HILLMER, S.C., BELL, W.R. and TIAO, G.C. (1983), "Modeling Considerations in the Seasonal Adjustment of Economic Time Series", in Zellner, A. (ed.), *Applied Time Series Analysis of Economic Data*, Washington, D.C.: U.S. Department of Commerce — Bureau of the Census, 74–100.

KOHN, R. and ANSLEY, C.F. (1985), "Efficient Estimation and Prediction in Time Series Regression Models", *Biometrika* 72, 694–697.

KOHN, R. and ANSLEY, C.F. (1986), "Estimation, Prediction and Interpolation for ARIMA Models with Missing Data", *Journal of the American Statistical Association* 81, 751–761.

MARAVALL, A. (1993), "Unobserved Components in Economic Time Series", EUI Working Paper ECO No. 93/34, Department of Economics, European University Institute. Forthcoming in Pesaran, H., Schmidt, P. and Wickens, M. (eds.), *The Handbook of Applied Econometrics*, vol. 1, Oxford: Basil Blackwell.

MARAVALL, A. and GÓMEZ, V. (1992), "Signal Extraction in ARIMA Time Series — Program SEATS", EUI Working Paper ECO No. 92/65, Department of Economics, European University Institute.

MÉLARD, G. (1984), "A Fast Algorithm for the Exact Likelihood of Autoregressive–Moving Average Models", *Applied Statistics* 35, 104–114.

MORF, M., SIDHU, G.S. and KAILATH, T. (1974), "Some New Algorithms for Recursive Estimation on Constant, Linear, Discrete–Time Systems", IEEE *Transactions on Automatic Control*, AC — 19, 315–323.

TIAO, G.C. and TSAY, R.S. (1983), "Consistency Properties of Least Squares Estimates of Autoregressive Parameters in ARMA Models", *The Annals of Statistics* 11, 856–871.

TSAY, R.S. (1984), "Regression Models with Time Series Errors", *Journal of the American Statistical Association* 79, 118–124.

2 Instructions for the User

2.1 Hardware Requirements

This version of TRAMO is compiled with the Microway NDP Fortran386 - Ver. 4.0.2 and Microsoft Fortran77 Ver. 5.0, linked with the Microway 386 Linker Ver. 4.0.2 and Microsoft Fortran77 Linker Ver. 5.0.

The present release breaks the 640K barrier by utilizing the full 32–bit addressing mode available on 80386 machines; it can run only on 80386–based computers (80486) that have at least 2MB of extended memory. A release that runs with conventional memory is available (it requires at least 540KB of memory).

Executing TRAMO requires the following hardware:

- an Intel 80386, 80386sx, or 80486–based IBM–compatible PC;
- for floating–point operations, a numberic coprocessor compatible with the CPU such as: 80387 or 80387sx;
- a 3.5" diskette drive;
- a hard disk with about 2MB of free space;
- at least 2MB of extended memory;
- MS–DOS V3.3 or greater;
- a video graphics adapter VGA, EGA, CGA (color video is recommended).

2.2 Installation

Insert the diskette in drive A or B and change the default drive (type "A:" or "B:"); when the prompt appears, type **INSTALL**.

The installation procedure asks you for the name of directory in which TRAMO will be installed; by default the directory is TRAMO (in this case be sure it does not already exist).

Three subdirectories are created: SERIES, GRAPH and OUTPUT. The input files should be prepared in the SERIES subdirectory.

TRAMO uses two environment variables **SLIB** and **SERIES** to find the files needed to run. The variable SLIB is the path to look for the graphics library, the variable SERIES is the path to look for the series.

By default (if you install the program on C:\TRAMO) the values for these variables are SLIB = C:\TRAMO\LIB and SERIES = C:\TRAMO\SERIES, so no action is necessary.

If you specified a different directory for TRAMO, you must set them as needed; put in your AUTOEXEC.BAT the following two lines:

SET SLIB = *path*\LIB
SET SERIES = *path*\SERIES

where *path* is the full path name of the directory where the program is installed.

2.3 Execution of the Program

Once in TRAMO type: **INPUT**

This is a very simple usable program to prepare the input file for the main program TRAMO. It shows a list of the available series (in the directory specified by variable SERIES) and, after you have selected one of them, it permits to set the values of the program parameters showing a list of all default values.

The program allows some simple facilities:

"q" to exit;

"h" to see default parameter values;

"l" to list already set parameters.

Set the parameters typing them one by one according to the following syntax:

parameter–name = parameter–value

Once all (non–default) parameter values have been set, in the next line type "end". This creates the file SERIE, containing the data and parameter values for the main program. Of course the file SERIE can be edited directly; this will typically be more convenient when minor changes are desired on an already existing SERIE file.

Having, thus, the SERIE file ready, to run the program type **TRAMO**. Alternatively, TRAMO can be run on a bat file by simply typing Tramo *filename*.

2.4 Output File

You can see the result of the program by editing or printing the file *serie-name*.OUT in the subdirectory OUTPUT.

As mentioned earlier, several arrays are stored in the subdirectory GRAPH, from which they can be easily retrieved. A table describing the meaning of each array is contained in the Appendix.

2.5 Graphics

Typing **GRAPH** you can see some graphics on the screen. The program selects the better graphics resolution for you (if you have any graphics adapter). Running the program, files are created in the subdirectory GRAPH, containing all relevant output arrays (used by GRAPH program), from which they can be retrieved for further use in packages such as SAS, MATLAB and GAUSS or for further numerical analysis. This version also supports direct laser–jet prints of the graphics produced. Typing the command "egalaser" from the prompt (before calling GRAPH), and calling GRAPH with the option **"-P"**, the file GRAPH.LHJ is created which can then be printed.

Different graphs (such as the series, the trend, and the seasonally adjusted series, for example) can be compared through an OVERLAY facility. Further, graphs from different runs of TRAMO can be simultaneously plotted. When exiting GRAPH (after its execution), you will be asked if you wish a backup copy of the graphics. By typing Y, the graphs are copied in the directory GRAPH, in the files *seriesname.bk1*, and *seriesname.n1*. (If a backup was previously made, then the files become *.bk2* and *.n2*.) In the next execution of GRAPH, you will have the option of comparing the new and old graphics (by typing 77). The maximum number of models that can be compared is 3.

Warning: The files *seriesname.bk1* and *seriesname.n1* are not automatically erased at the next execution of TRAMO. By typing (from \TRAMO)

CLEAN,

all previous backups will be erased from the directory GRAPH.

2.6 Printing TRAMO User's Manual

In the directory MANUAL you can find the file EXTMAN.EXE, a self–extracting compressed file. It contains a POSTSCRIPT copy of the TRAMO user manual.

In order to print it, type "EXTMAN" from the DOS prompt; this command produces a file TRAMO.PS, and then you can print it in your POSTSCRIPT printer.

2.7 Downloading TRAMO Using FTP Anonymous

The PC MS–DOS programs SEATS and TRAMO are now available to anyone, on the INTERNET, without requiring a login and password. The following is one way to download the programs from Datacomm.iue.it:

Step 1: FTP 149.139.6.101 using login name as 'anonymous', password as your E–mail address. Go to the directory 'seats–tramo'. This directory contains three files:

- extseats.exe (SEATS self–extracting compressed program)
- exttramo.exe (TRAMO self–extracting compressed program)
- readme (these instructions).

Step 2: Change the transfer type to binary in order to upload binary compressed files and retrieve the three files.

Step 3: Transfer the files on your PC.

Step 4: When on your PC, in order to install the programs, type (from DOS prompt): "EXTSEATS -d" and "EXTTRAMO -d"; the two programs will be installed in the directory SEATS and TRAMO, respectively.

3 Description of the Input Parameters

3.1 ARIMA Model

Parameter		Meaning	Default
MQ	=	Number of observations per year (12 for monthly, 6 for bimonthly, 4 for quarterly, 1 for annual)	12
LAM	= 1	No transformation of data	0
	= 0	Take logs of data	
IMEAN	= 0	No mean correction	1
	= 1	Mean correction	
D	=	# of non–seasonal differences	1
BD	=	# of seasonal differences	1
P	=	# of non–seasonal autoregressive terms	1
BP	=	# of seasonal autoregressive terms	0
Q	=	# of non–seasonal moving average terms	1
BQ	=	# of seasonal moving average terms	1
TH	=	*Q* initial estimates of the regular moving average parameters (not input if *INIT*=0 and *JQR(I)*=0 for all *I*).	All -.1
BTH	=	*BQ* initial estimates of the seasonal moving average parameters (not input if *INIT*=0 and *JQS(I)*=0 for all *I*).	All -.1
PHI	=	*P* initial estimates of the regular autoregressive parameters (not input if *INIT*=0 and *JPR(I)*=0 for all *I*).	All -.1
BPHI	=	*BP* initial estimates of the seasonal autoregressive parameters (not input if *INIT*=0 and *JPS(I)*=0 for all *I*).	All -.1
JPR(I)	= 1	Parameter number I in the regular autoregressive polynomial fixed to the value set in *PHI(I)* (it is not estimated)	0
	= 0	Parameter not fixed.	
JPS(I)	= 1	Parameter number I in the seasonal autoregressive polynomial fixed to the value set in *BPHI(I)* (it is not estimated)	0
	= 0	Parameter not fixed.	

Parameter		Meaning	Default
JQR(I)	= 1	Parameter number I in the regular moving average polynomial fixed to the value set in *TH(I)* (it is not estimated)	0
	= 0	Parameter not fixed.	
JQS(I)	= 1	Parameter number I in the seasonal moving average polynomial fixed to the value setin *BTH(I)* (it is not estimated)	0
	= 0	Parameter not fixed.	

3.2 Automatic Model Identification

INIC	= 0	No automatic model identification is performed	0
	= 2	Used for automatic model identification. The program searches for regular polynomials up to order 2, for seasonal MA polynomials up to order 2 and for seasonal AR polynomials up to order 1 (not input if *IDIF*=0)	
	= 3	Used for automatic model identification. The program searches for regular polynomials up to order 3, for seasonal MA polynomials up to order 2 and for seasonal AR polynomials up to order 1 (not input if *IDIF*=0)	
	= 4	Used for automatic model identification. The program searches for regular polynomials up to order 3 and for seasonal polynomials up to order 2 (not input if *IDIF*=0).	
IDIF	= 0	No automatic model identification.	0
	= 1	Used for automatic model identification. The program searches for regular differences up to order 2 and for seasonal differences up to order 1 and then it stops. Used with *INIC*>1 and *IMEAN*=0	
	= 2	Used for automatic model identification. The program accepts the regular (*D*) and seasonal (*BD*) differences entered by the user. Used with *INIC*>1	
	= 3	Same as with *IDIF*=1, but the program does not stop. It continues with the identification of an ARMA model for the differenced series. Used with *INIC*>1 and *IMEAN*=0	
	= 4	Same as *IDIF*=1, but the program also searches for unit complex roots	
	= 5	Same as *IDIF*=3, but the program also searches for unit complex roots.	

Parameter		Meaning	Default
UB1	=	If one of the roots in the "AR(1) × $AR_s(1)$ plus mean" estimation in the first step of the automatic identification of the differencing polynomial is larger than *UB1*, in modulus, it is set equal to unity.	.96
UB2	=	If one of the roots in the "ARMA(1) × $\text{ARMA}_s(1)$ plus mean" estimation in the second step of the automatic model identification is larger than *UB2*, in modulus, it is set equal to unity.	.88
CANCEL	=	If the difference in moduli of an AR and an MA root (when estimating ARMA(1,1) × $\text{ARMA}_s(1,1)$ models in the second step of the automatic identification of the differencing polynomial) is smaller than *CANCEL*, the two roots cancel out.	.10
IMVX	=	See Section 6 ("Outliers").	

For automatic identification of a model, there are two steps: First, the program identifies the degrees of differencing (*IDIF*=1,2,3,4,5) and later, the program identifies an ARMA model for the differenced series (*INIC*=2,3,4). If *IDIF*=1, then the program stops after obtaining the degrees of differencing. If *IDIF*=2, the program accepts the degrees of differencing entered by the user (*D* and *BD*), together with the mean specification, and goes on to obtain the ARMA model identification (*INIC*=2,3,4). If *INIC*=3, the program obtains the degrees of differencing and goes on to obtain the ARMA model identification (*INIC*=2,3,4). *IDIF*=4 and 5 are as *IDIF*=1 and 3, respectively, but the program also checks for the presence of unit complex roots. With *IDIF*=1,3,4,5, the program generates mean correction if needed, so *IMEAN* should be input as 0. When the series is thought to contain many outliers, the use of *IMVX*=2 is recommended.

3.3 Estimation

Parameter		Meaning	Default
INCON	= 0	Exact maximum likelihood estimation	0
	= 1	Unconditional least squares (only to use with *IFILT*=1,2 or 3).	
INIT	= 0	Estimation of unknown parameters and starting values computed by the program	0
	= 1	Estimation of unknown parameters with starting values input by the user	
	= 2	No estimation.	

Parameter		Meaning	Default
IFILT	= 1	Square root filter	2
	= 2	Morf, Sidhu and Kailath algorithm, as improved by Mèlard	
	= 3	Ordinary Kalman filter	
	= 4	Conditional least squares.	
IDENSC	= 1	Denominator of residual sum of squares is that of Ansley and Newbold = number of non–initial observations minus number of unknown parameters (AR and MA parameters plus regression parameters, including outliers and initial missing observations)	1
	= 0	Denominator of residual sum of squares is equal to the number of non–initial observations.	
TOL	=	Convergence criterion in Gauss–Marquardt's method.	1.E-4
ICONCE	= 1	σ^2 and regression parameters (including outliers and missing initial observations) concentrated out of the likelihood	1
	= 0	Only σ^2 concentrated out of the likelihood.	
UBP	=	If an AR root found in the estimation of the ARMA model parameters is larger than *UBP*, it is set equal to one.	.97
M	=	# of autocorrelations and partial autocorrelations printed.	36
IQM	=	# of autocorrelations used in computing *Q*–statistics.	24*
IROOT	= 1	Roots of all AR and MA polynomials are computed	2
	= 0	Roots not given	
	= 2	Roots of all AR and MA polynomials are computed, and the former are set automatically as unit roots if their modulus is larger than *UBP*.	

(*) The default value of *IQM* depends on *MQ*. For $MQ = 12$, $IQM = 24$; for $MQ = 2,3,4,6$, $IQM = 4 \times MQ$; for $MQ = 1$, $IQM = 8$.

3.4 Forecasting

Parameter		Meaning	Default
NBACK	= > 0	# of observations back from the end of the data that the multistep forecasts are to begin	0

Parameter		Meaning	Default
	= < 0	# of observations that are omitted from the end of the series. The program works with less observations and so the user can test model adequacy by forecasting the deleted observations.	
NPRED	=	# of multistep forecast values to compute.	0

3.5 Missing Observations

INTERP	= 0	No interpolation of unobserved values and missing observations treated using the skipping approach	0
	= 1	Interpolation of unobserved values and missing observations treated using the skipping approach	
	= 2	Missing observations are treated as additive outliers (initial values are constructed as the sum of the two adjacent observations; interpolation is always performed.	
ICDET	= 1	A proper correction is made in the determinantal term of the likelihood when missing observations are treated as additive outliers	1
	= 0	No correction is made in the determinantal term.	

Missing observations can be treated in two ways: Skipping approach (*INTERP*=0,1) and additive outliers approach (*INTERP*=2). If *ICDET*=1 and *INTERP*=2, the determinantal term in the function to be minimized is adjusted so that it coincides with that of the function used in the skipping approach. When the model is identified with the automatic option, missing observations are estimated with the additive outlier approach (*INTERP*=2).

3.6 Outliers

VA	=	If *IATIP*=1, it is used to set the critical value for outlier detection (not input if *IATIP*=0).	4.0
IATIP	= 1	Automatic detection and correction of four types of outliers (*IO, AO, LS, TC*) is performed. If *IMVX*=0, the fast method of Hannan–Rissanen is used for estimation of parameters. If *IMVX*=1,3 (see below), then maximum likelihood estimation is used	0

Parameter		Meaning	Default
	= 2	(Not input if *INIC*<2) same as 1, but the program, after corrrecting for the outliers found, obtains a new model and searches for outliers again with this new model. In this second round, the critical level *VA* is reduced by an amount of *PC* per cent	
	= 0	No outlier detection is performed.	
IMVX	= 0	The fast method of Hannan–Rissanen is used for parameter estimation in the automatic detection and correction of outliers (not input if *IATIP*=0)	0
	= 1	Maximum likelihood estimation is used for parameter estimation in the automatic detection and correction of outliers (not input if *IATIP*=0)	
	= 2	First, unconditional least squares and then exact maximum likelihood is used in the estimation of the unit roots in the automatic model identification. If *IATIP*>0, then estimation of outliers is made with the Hannan–Rissanen procedure	
	= 3	As *IMVX*=2, but, if *IATIP*>0, outliers correction is made with the exact maximum likelihood procedure. This procedure, although relatively time consuming, may be of interest when the series contains many outliers.	
PC	=	Percentage by which VA is reduced in the second round when *IATIP*=2 ($\times 10^{-2}$).	.10
AIO	= 0	The program corrects for the four types of outliers described below.	1
	= 1	All outliers are treated as additive outliers or transitory changes (in this way the level of the series is preserved). This option is of particular interest when TRAMO is used as a preadjustment program for SEATS.	

Detection and correction of outliers is made with a procedure similar to that in Chen and Liu (1993), with some important modifications (namely, exact residuals are used; the algorithm is simpler; estimation, based on two simple regressions, is faster; and the parameter estimates are modified at each iteration). Four kinds of outliers can be identified and corrected by the program. Innovational outliers (*IO*), additive outliers (*AO*), level shifts (*LS*) and temporary changes (*TC*). This last one being equal to an impulse divided by 1-.7*B*. If *IATIP*=1 and *INIC*=0, the program performs the identification and correction of the four kinds of outliers using the model entered by the user. Critical values recommended are: 2.8 for high sensitivity, 3.2 for medium sensitivity and 3.5 for low sensitivity with series of medium length ($\leq$150) and 3.0, 3.5 and 4.0, respectively, for series of length >150.

If automatic outlier identification and correction (*IATIP*>0) is to be performed along with automatic model identification (*INIC*>2), the sequence of actions is as follows. After obtaining the degrees of differencing, either automatically (*IDIF*=3) or accepting those entered by the user (*IDIF*=2), if *IATIP*=1, the program obtains first a model using the BIC criterion and then performs the automatic identification and correction of outliers using the previously identified model. But if *IATIP*=2, there are two rounds: first, the program accepts the model entered by the user and corrects the series for the outlier effects. Then, it returns to model identification and further outlier identification and correction, using the model obtained in the second round and a critical level equal to (1-*PC*) times that of the first round.

Since level shifts and, in particular, innovational outliers (specially at the beginning of the series) may have, on occasion, very drastic effects on the level of the series, by default *AIO*=1, so that only local deviations from the mean level are allowed.

3.7 Regression

IREG	=	# of regression variables (entered by the user or calculated by the program as intervention variables.		0
ITRAD	= 0	No trading day adjustment		0
	= 1	Trading day adjustment.		
IEAST	= 0	No easter effect adjustment		0
	= 1	Easter effect adjustment.		
IDUR	=	Duration of easter affecting period (# of days).		0
RG	=	*IMEAN+IREG+ITRAD+IEAST* initial estimates of the regression parameters, not including initial missing observations (not input if there are not missing observations or *ICONCE*=1).		All 0.1

If *IREG* in namelist *INPUT* is greater than zero, then namelist *INPUT* should be followed by a certain number of namelist *REG*, to be specified below. Each namelist *REG* starts with &*REG* (in the second column), terminates with / and contains the set of instructions for the corresponding regression variable(s).

Parameter		Meaning	Default

The total number of namelists *REG* is as follows: There must be as many namelists *REG* following namelist *INPUT* as there are regression variables not entered by the user, plus one namelist *REG* for each file containing regression variables entered by the user.

The parameters in namelist *REG* are:

IUSER	= 1	The user will enter a series for this regression variable. After the present namelist *REG*, the user will write the series X(I): I=1, *ILONG* (free format). After the series, next namelist *REG* should be written	0
	= -1	The program will read *NSER* series from the file whose name is written after the present namelist *REG*. There must be *NSER* columns of length *ILONG* in this file separated by blanks, containing the *NSER* series (*NSER*>0 must be input)	
	= 0	The user does not provide any series	
	= 2	The user specifies the presence of some outliers. Then *NSER* is equal to the number of specified outliers, and is followed by a sequence of pairs of numbers (free format): $t_1 \quad j_1 \quad t_2 \quad j_2 \quad \ldots t_{NSER} \quad j_{NSER}$ where $t_1 \quad \ldots \quad t_{NSER}$ denote the position of the outlier ($t = 1, \ldots, T$), and $j_1, \ldots, j_{NSER}$ denote the type of outlier according to the following code: J_i = 1 Innovation outlier; = 2 Additive outlier; = 3 Level shift; = 4 Temporary change.	
NSER	= *k*	(*k* a positive integer) number of series entered by the user in an external file (if *IUSER*=-1), or number of outliers specified by the user (if *IUSER*=2)	0
	= 0	No series entered by the user in any external file.	
ILONG	=	Length of the series entered by the user if *IUSER*=1, -1. The rest of the series, up to a total length of *NZ+NPRED* is filled up with zeroes (not input if *IUSER*=0).	0
ISEQ	= *k*	(*k* = a positive integer). The program will generate one intervention variable of length *NZ+NPRED* consisting of *k* sequences of ones. After the present namelist *REG*, the user will write *k* pairs of numbers (free format); the *k*–th pair indicates the time	

Parameter		Meaning	Default
		index where the k–th sequence of ones is to begin and its length, respectively. The k pairs of numbers are to be followed by the next namelist *REG* (no input if *IUSER*=1)	0
	= 0	The program will generate no regression variable.	
DELTA	=	$\delta(0 < \delta \leq 1)$; the filter $1/(1-\delta B)$ will be applied to the k–sequences of ones generated by the program (no input if *IUSER*=1,-1).	0
DELTAS	=	$\delta_s(0 < \delta_s \leq 1)$; the filter $1/(1-\delta_s B^s)$, s=*MQ*, will be applied to the k–sequences of ones generated by the program (no input if *IUSER*=1,-1).	0
ID1DS	= 1	The program will generate $1/(1-B)(1-B^s)$, s=*MQ*, of the k–sequences of ones generated by the program (no input if *IUSER*=1,-1).	0

Notice that *IREG* should equal the number of namelists *REG* with *IUSER*=1, plus *NSER* for each namelist *REG* with *IUSER*=-1 or 2.

The regression variables used to make the trading day or easter effect adjustment are generated by the program in the same way as that described in Hillmer, Bell, and Tiao (1983). The aggregate trading day effect is normalized so as to preserve the mean level of the series.

3.8 Others

PG	= 0	Creates output files in the subdirectory *GRAPH*	0
	= 1	No output files in *GRAPH*.	
ITER	= 0	One series, one model	0
	= 1	Several models are provided by the user to be applied by the program to the same series	
	= 2	Several series are to be treated by the program with the same model	
	= 3	Several series, each with its own specified model, are treated by the program	
	= 4	As *ITER*=3, but no arrays are stored.	

Parameter		Meaning	Default
SEATS	= 0	No input file for SEATS is created	0
	= 1	Creates input file for SEATS redoing estimation in SEATS. The name of this file will be **SEATS.ITR**	
	= 2	Creates input file for SEATS and no estimation is performed in SEATS. The name of this file will be **SEATS.ITR**.	
UR, XL	=	When SEATS=2, if the modulus of an estimated root in the AR polynomial falls in the range (*XL*, 1), it is set equal to *UR*. If the root is in the MA polynomial, it is set equal to *XL*. (Used only when *SEATS*=2.)	1, .98

In order to execute SEATS, the file *SEATS.ITR* should be passed on to the directory *SEATS* as "*serie*". The model contained in *SEATS.ITR* should satisfy the constraint, imposed by SEATS, that the total autoregrerssive order ($P{+}D{+}BP{\times}MQ + BD{\times}MQ$) $\geq$ the total moving average order ($Q{+}BQ \times MQ$).

When *ITER*=1, the names of the output file are *MODEL1.OUT*, ..., *MODELn.OUT*, where n is the number of iterations (if *ITER*=2,3 the usual *seriename.OUT*).

The structure of the input file *SERIE* if *ITER*>0 is the following:

ITER = 1 You have to append (in any format) at the end of the usual input file the number of namelist *INPUT* (and eventually namelist *REG*) that you want; remember that the structures of namelist *INPUT* and *REG* are the following:

&INPUT *parameter–name=parameter–value, ..., parameter–name=parameter–value, /*

&REG *parameter–name=parameter–value, ..., parameter–name=parameter–value, /*

ITER = 2 You have to append (in any format) at the end of the usual input file the number of series that you want, according to the following convention:

1^{st} *line:*	title
2^{nd} *line:*	number of observations
	starting year
	starting period
	frequency
3^{rd} *to* n^{th} *line:*	observations in any format.

Parameter		Meaning	Default
ITER	= 3,4	You have to append (in any format) at the end of the usual input file the number of pairs series–namelist that you want; the convention for the series is the same as in *ITER*=2, and for the namelist the same as in the case *ITER*=1.	

When *ITER*$\neq$0, the files for *GRAPH* are not computed. For *ITER*=2,3, the directory OUTPUT contains the standard output file, plus the original and linearized series. When *ITER*=4, only the output file is contained.

Further, when *ITER*$\neq$0, the program *INPUT* should not be executed. The input file is entered directly in *serie*, and then TRAMO can be executed. Alternatively, if: **** denotes the bat file, simply type tramo ****.

3.9 Memory Constraints

The user should be aware of the following memory constraints:

IFILT=2	$2+2\times IMRTE\leq 44$ $IR+2 + ICON\leq 44$
IFILT=3	$1+2\times IMRTE + IMISP\leq 44$ $MAX\{IR+1, ICON\} + ICON\leq 44$
IFILT=1	like *IFILT*=3
In all cases	$MAX\{N, ICON\} + N+1\leq 44$, $NZ\leq 250$ $NZ+NPRED\leq 294$,

where $IMRTE=IMEAN+IREG+7\times ITRAD+IEAST$, $IMISP=$ number of initial missing values, $ICON=(MIN\ \{ICONCE, 1\})\times(IMRTE+IMISP)+1$, $IR=MAX\ \{ID+IP, IQ+1\}$ if *IFILT*=1 or 3, $IR=MAX\ \{IP, IQ+1\}$ if *IFILT*=2 or 4, $ID=D+MQ\times BD$, $IP=P+MQ\times BP$, $N=$ number of parameters to be estimated by Gauss–Marquardt's method.

4 Input File and Examples

The input starts with the series to be modelled, comprising no more than 250 observations, followed by one set of control parameters for the series model plus a list of instructions for the regression variables.

To specify the set of control parameters for the series model, as well as the instructions for the regression variables, the NAMELIST facility is used, so that only those parameters which are not at their default values (see below) need to be set.

The series is set up as:

Card 1	TITLE (no more than 72 characters)
Card 2	NZ NYER NPER NFREQ (free format)
Card 3 et seq.	Z(I): I = 1, NZ (free format),

where NZ is the number of observations, NYER the start year, NPER the start period, and NFREQ is an instruction to control table format (the number of columns). Z(.) is the array of observations. For each missing observation, the code -99999. must be entered. (The first nonblank characters of TITLE are used by the program to create a file named ********.OUT in the subdirectory OUTPUT containing the output of the program.)

This is followed by namelist INPUT. The namelist starts with &INPUT (in the second column) and terminates with /.

Four examples of input files are provided. They contain series that have been previously analyzed in the time series literature.

Example One illustrates the case in which the default model is used on several series. For each one of them, the ARIMA model

$$\nabla \nabla_{12} \log z_t = (1 + \theta_1 B)(1 + \theta_{12} B)\, a_t + c$$

is estimated by the exact maximum likelihood method, with starting values computed by the program. A simplified Morf–Sidhu-Kailath algorithm is used.

Series 1A is the airline passenger series in Box and Jenkins (1970); series 1B and 1C are the UK and Italian monetary aggregate series in Maravall (1993).

Example Two illustrates the case in which missing observations and regression variables (intervention variables constructed by the program) are present. The model is given by the equations

$$z_t = \frac{\omega_0}{1-B}\, d_{1t} + \frac{\omega_2}{1-B^{12}}\, d_{2t} + \frac{\omega_3}{1-B^{12}}\, d_{3t} + n_t$$

$$(1+\phi B)\,\nabla_{12}\,n_t = (1+\theta_{12}B^{12})\,a_t,$$

where

$$d_{1t} = \begin{cases} 1 & t = \text{January 1960} \\ 0 & \text{otherwise} \end{cases}$$

$$d_{2t} = \begin{cases} 1 & \text{months June–October, beginning in 1966} \\ 0 & \text{otherwise} \end{cases}$$

$$d_{3t} = \begin{cases} 1 & \text{months November–May, beginning in 1966} \\ 0 & \text{otherwise.} \end{cases}$$

Forecasts of the series z_t are computed for the next 24 months. The series contains 8 missing observations, and the first one falls among the first 12 values. By default, in estimation, this first missing observation, as well as the regression parameters, are concentrated out of the likelihood, which is computed with the ordinary Kalman filter. The interpolators of the missing observations are obtained with a simplified fixed point smoother.

Series 2 is the ozone level series in Box and Tiao (1975).

Example Three illustrates the use of the automatic model identification and automatic outlier detection and correction facilities. The regular and seasonal orders of differencing, as well as the stationary ARMA model, will be automatically selected. Notice that, after correcting for the outliers found, the full ARIMA model is identified again, and a second outlier detection and correction will be performed.

The program will compute 24 forecasts of the series. It will further create a file containing the series corrected for outliers, ready for use by a companion program (SEATS). In this example, the file passed on to SEATS contains the linearized series and the orders of the ARIMA model; SEATS reestimates the parameters with the method described in Burman (1980). Program SEATS is a model–based seasonal adjustment (more generally, unobserved components estimation) program for linear time series, described in Maravall and Gómez (1992).

Series 3 is the monthly series of retail sales of variety stores in Chen, Liu, and Hudak (1990).

Example Four The program fits the model (z_t denotes the logged variable)

$$z_t = \alpha\,H(\tau, T) + \sum_{i=1}^{7} \beta_i\,T_{it} + n_t,$$

where $H(\cdot)$ denotes the easter effect, $T_{1t}, \ldots, T_{7t}$ are the trading day effects, and n_t follows the model

$$(1+\phi_1 B)\,\nabla\nabla_{12}\,n_t = (1+\theta_2 B^2)\,(1+\theta_{12}B^{12})\,a_t,$$

with θ_1 constrained to be zero. Estimation is carried by exact maximum likelihood, and automatic detection of and correction for outliers is made. So as to preserve the level, all outliers are forced to be either additive outliers or transitory changes. The original series, and the series corrected for easter and trading day effects and for outliers, are passed on to SEATS, together with the ARIMA model, including the parameter estimates (no reestimation is done by SEATS).

This example represents what could be a standard way of running TRAMO when used as a preadjustment program for SEATS. (Although for many groups of series, the trading day and easter effect correction may well be unnecessary.)

Series 4 is the monthly sales of U.S. men's and boys' clothing stores in Hillmer, Bell, and Tiao (1983).

EXAMPLE1

```
SERIE1A
144    1949 1 12
112 118 132 129 121 135 148 148 136 119 104 118
115 126 141 135 125 149 170 170 158 133 114 140
145 150 178 163 172 178 199 199 184 162 146 166
171 180 193 181 183 218 230 242 209 191 172 194
196 196 236 235 229 243 264 272 237 211 180 201
204 188 235 227 234 264 302 293 259 229 203 229
242 233 267 269 270 315 364 347 312 274 237 278
284 277 317 313 318 374 413 405 355 306 271 306
315 301 356 348 355 422 465 467 404 347 305 336
340 318 362 348 363 435 491 505 404 359 310 337
360 342 406 396 420 472 548 559 463 407 362 405
417 391 419 461 472 535 622 606 508 461 390 432
 &INPUT ITER=2,/
SERIE1B
108 1983 1 12
  108.64 110.434 111.865 112.468 113.505 114.954
 115.285 115.011 114.958 116.037 116.706 120.764
 121.446 122.291 124.407 125.776 127.688 129.257
 130.012 129.857 130.213 130.503 133.326 134.786
 133.782 134.737 136.544 136.465 137.18  138.315
 138.887 140.477 142.308 143.483 146.263 147.5
 147.996 149.05  151.487 153.134 154.861 158.711
 161.668 161.718 164.456 165.476 166.729 168.914
 168.015 168.102 170.987 172.818 174.516 178.183
 179.13  179.696 181.548 182.15  185.566 187.312
 187.698 189.498 192.676 194.023 197     203.392
 205.718 207.506 211.137 212.442 213.038 217.206
 213.238 215.411 218.884 219.984 221.757 224.353
 224.978 226.363 230.009 231.303 233.595 236.257
 233.194 234.621 239.062 241.909 241.932 245.486
 246.803 245.61  250.041 251.344 250.893 255.202
 256.994 257.329 263.587 266.441 267.93  271.047
 270.294 270.293 273.265 273.806 275.476 278.286
SERIE1C
84      1985 1 12
  476858 470452 467356 470150 470283 469158 475737 477899
  480247 484607 487504 496028 528482 512452 506006 507463
  505680 504057 508409 509540 514937 521942 529215 548856
  571276 558634 554490 559007 561062 560722 566622 565298
  566132 572547 578118 588218 610607 592251 587350 592605
  595206 593858 606122 605947 610244 621219 623082 633041
  654948 635525 635335 645359 649944 644572 658989 655998
  658583 664989 668843 695759 726651 702632 695135 705275
  707122 697616 711288 706823 721195 728682 733149 752883
  771704 758786 757519 759669 765061 759573 769051 763938
  771354 782924 793938 820872
```

EXAMPLE2

```
SERIE2
216    1955 1 12
2.7  2.0 -99999. 5.0  6.5  6.1  5.9  5.0  6.4  7.4  8.2  3.9
4.1  4.5  5.5  3.8  4.8  5.6  6.3  5.9 -99999. 5.3  5.7  5.7
3.0  3.4  4.9  4.5  4.0  5.7  6.3  7.1  8.0  5.2  5.0  4.7
3.7  3.1 -99999. 4.0  4.1  4.6 -99999. 4.2  5.1  4.6  4.4  4.0
2.9  2.4  4.7  5.1  4.0  7.5  7.7  6.3  5.3  5.7  4.8  2.7
1.7  2.0  3.4  4.0  4.3  5.0  5.5  5.0  5.4  3.8  2.4  2.0
2.2  2.5  2.6  3.3  2.9  4.3  4.2  4.2  3.9  3.9  2.5  2.2
2.4  1.9  2.1  4.5  3.3  3.4  4.1  5.7  4.8  5.0  2.8  2.9
1.7  3.2  2.7  3.0  3.4  3.8  5.0  4.8  4.9  3.5  2.5  2.4
1.6  2.3  2.5  3.1 -99999. 4.5  5.7  5.0  4.6  4.8  2.1  1.4
2.1  2.9  2.7  4.2  3.9  4.1  4.6  5.8  4.4  6.1  3.5  1.9
1.8  1.9  3.7  4.4  3.8  5.6  5.7  5.1  5.6 -99999. 2.5  1.5
1.8  2.5  2.6  1.8  3.7  3.7  4.9  5.1  3.7  5.4  3.0  1.8
2.1  2.6  2.8  3.2  3.5  3.5  4.9  4.2  4.7  3.7  3.2  1.8
2.0 -99999. 2.8  3.2  4.4  3.4  3.9  5.5  3.8  3.2  2.3  2.2
1.3  2.3  2.7  3.3  3.7  3.0  3.8  4.7  4.6  2.9  1.7  1.3
1.8  2.0  2.2  3.0  2.4  3.5  3.5  3.3  2.7  2.5  1.6  1.2
1.5  2.0  3.1  3.0  3.5 -99999. 4.0  3.8  3.1  2.1  1.6  1.3
 &INPUT
NPRED=24,LAM=1,IREG=3,IFILT=3,INTERP=1,IMEAN=0,P=1,Q=0,SEATS=1,
d=0,/
 &REG ISEQ=1, DELTA=1.D0,/
  61 1
 &REG ISEQ=8,DELTAS=1.D0, /
  138 5 150 5 162 5 174 5 186 5 198 5 210 5 222 5
 &REG ISEQ=8,DELTAS=1.D0, /
  143 7 155 7 167 7 179 7 191 7 203 7 215 7 227 7
```

EXAMPLE3

```
SERIE3
153    1967 1 12
 296  303  365  363  417  421  404  436  421  429  499  915
 331  361  402  426  460  457  451  476  436  464  525  939
 345  364  427  445  478  492  469  501  459  494  548  1022
 370  378  453  470  534  510  485  527  536  553  621  1122
 394  411  482  484  550  525  494  537  513  521  596  1069
 393  425  503  529  581  558  547  588  549  593  649  1191
 463  459  554  576  615  619  589  637  601  642  737  1279
 490  490  598  615  681  654  637  694  645  684  749  1245
 489  511  612  623  726  692  623  734  662  684  781  1386
 503  537  636  560  607  585  559  608  556  596  665  1229
 427  450  573  579  615  601  608  617  550  616  673  1199
 438  458  548  584  639  616  614  647  588  648  713  1261
 483  483  593  620  672  650  643  702  654
 &INPUT NPRED=24,IDIF=3,INIC=3,VA=3.2,IATIP=2,SEATS=1,/
```

EXAMPLE4

```
SERIE4
153   1967 1 12
 237   187   241   245 259 296 252 260 271 267 320 549
 266   216   252   297 302 310 270 288 280 316 372 594
 319   249   287   320 342 329 291 321 315 361 400 680
 338   268   304   313 348 350 321 317 333 364 396 719
 336   267   303   375 382 401 341 351 357 382 447 771
 364   310   379   408 439 451 390 413 424 469 534 884
 452   361   426   470 477 502 424 442 442 479 562 961
 437   368   427   495 514 492 443 500 458 492 542 889
 459   403   490   467 556 542 474 510 483 527 591 1044
 495   404   463   540 518 552 505 502 496 558 629 1137
 511   440   496   578 542 550 492 518 507 569 708 1141
 480   421   532   536 542 563 508 554 552 609 763 1293
 561   462   564   582 586 615 553 612 570
 &INPUT IMEAN=1,P=1,Q=2,JQR(1)=1,TH(1)=0,IEAST=1,IDUR=9,ITRAD=1,
 IATIP=1,VA=3.5,AIO=1,SEATS=2,/
```

5 Appendix: Identification of the Arrays Produced by TRAMO

Description of the Files in GRAPH

5.1 Series

Meaning	Title of Graph	Name of File
Original series	Original Series	*xorig.out*
Series with missing observations interpolated	Interpolated series	*xint.reg*
Forecast of the series	Forecast of the series	*pred.out*
Interpolated series with the effect of regression variables removed (the regression variables are those included in the namelists REG)	Reg. corr. series	*xcreg.reg*
Interpolated series corrected for outliers	Outlier corr. series	*xcout.reg*
Interpolated series corrected for special effects (Easter and Trading Day)	S.E. corr. series	*xcetd*
Interpolated series corrected for outliers, special effects, and for the effect of regression variables, not including the mean. (This is the series passed on to the companion program SEATS.)	Linear series	*xlin.reg*
White–noise residuals	Residuals	*resid.out*
Interpolated series minus "fitted" values, i.e., residuals from the ARIMA model applied to the linearized series.	Full residuals	*fresid.out*

Meaning	Title of Graph	Name of File

5.2 Autocorrelation Functions

ACF of white–noise residuals	ACF residuals	*auto.out*
Partial ACF of white–noise residuals	PACF residuals	*pauto.out*
ACF of squared (full) residuals	ACF sqd residuals	*autos.out*

5.3 Regression, Outliers, and Special Effects

Effect of the first regression variable	Reg1	*reg1*
...	...	...
Effect of the n^{th} regression variable	Regn	*regn*

The ordering of the regression variables is determined by the order in which the REG namelists have been entered in the input file. Note that n should be equal to the total number of variables in the namelists REG of the input file.

Aggregate regression effect	Total Reg.	*regsum*
Effect of the first outlier identified by the program	Outreg1	*outreg1*
...	...	...
Effect of the k^{th} outlier	Outreg*k*	*outregk*

The ordering of outliers is determined by the order in which they are detected in the program (i.e., the order in which outliers appear in the output file).

Aggregate outlier effect	Total Outliers	*outsum*
First trading day effect	Trad 1	*trad 1*
...	...	...
Seventh trading day effect	Trad 7	*trad 7*

Meaning	Title of Graph	Name of File
Aggregate trading day effect	Total Trad. Day	*tradsum*
Easter effect	East	*east*
Aggregate special effects (easter plus trading day)	Special Effects	*etdsum*
Aggregate regression, outlier, and special effects (i.e., difference between interpolated/original series and linearized series)	Total Reg-O-SE	*totrose*

Note that the previous arrays are saved in *GRAPH* when *ITER*=0. When *ITER*>0 (several series / several models), only the original and linearized series are saved, as *xorig*1*.out*, ..., *xorign.out*, *xlin*1*.out*, ..., *xlinn.out*. In this case they are stored in the subdirectory *OUTPUT* (not in *GRAPH*), together with the program output. When *ITER*=4, no arrays are stored; only the output file is produced.

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